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Food Waste Dilemma and Scenarios for Agri-tourism in Romanian's Mountain Region: An Analysis of Literature and Secondary Data

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Abstract

Food waste is a generalized process that affects both the environment and resources (natural, financial, sanitary, etc.). The negative effects are felt both at the individual level (household budget) and at the society level, and they are, as a rule, difficult to combat. From the existing quantitative and qualitative analyses, it was observed that food waste at household level represents over 50% of its total volume, even if food waste is produced throughout the supply chain. It is also noted that some economic sectors, by the nature of their activities, have a greater predilection to waste food. This study carried out on agro-tourist guesthouses in the mountainous area of Romania shows that, at their level, food waste has reduced. This is due to the household spirit and the ethical and spiritual values passed down from generation to generation, reflecting consumers' affection and respect to Romania's mountains. Solutions aimed at reducing waste generation vary, encompassing everything from raising awareness about it to re-evaluating practices, advocating for good habits, implementing innovative packaging, and more. In light of this, this article seeks to enhance understanding of food waste and to pinpoint viable strategies for addressing it. Furthermore, it endeavors to estimate the volume of food waste in mountainous region of Romania, particularly within tourist establishments. Findings reveal that the highest levels of waste occur in mountain hotels, closely followed by agro-tourism guesthouses. Thus, this article provides a concise overview of food waste in mountainous areas and underscores the importance of initiatives aimed at its direct or indirect reduction.

Keywords

Food waste; Sustainable development; Food behaviour; Mountain area; Agritourism

Introduction

Coastal buffer zones (CBZs) are an effective and sustainable means of protecting aquatic ecosystems from nutrient run-off actively used in agriculture and thus act as a buffer against nutrient removalAlong

with the multiple challenges that exist globally (population growth, pandemic crisis, geo-political crisis, climate change, land use pressures, etc.), there is a disturbing phenomenon that is getting worse. It is "food waste". At the same time, the reduction of food waste determines a series of positive effects on society: 1) reducing costs, 2) making food consumption more efficient, and 3) combating environmental pollution. According to estimates by the FAO, the annual cost of food waste is estimated to be 2.6 trillion USD (or 3.3% of global GDP); and benefits include the enhanced economy of some resources, the reduction or avoidance of the application of some fertilizers, and a reduction in the strain on arable land (FAO, 2014). EPA[1] estimated that each year, U.S. food loss and waste embodies 170 million metric tons of carbon dioxide equivalent (million $MTCO_{2e}$) GHG emissions (excluding landfill emissions) – equal to the annual CO_2 emissions of 42 coal-fired power plants.[2] Moreover, there was 80 million U.S. tons of food waste in the United States in 2021.[3]

In this context, reducing food waste becomes a legitimate target and a key priority of public, local, regional, national and global policies, but also an assumed wish for every inhabitant of the planet. This aspect is even more relevant in the context of the sustainable development goals established by the United Nations, which advocates a "responsible consumption/production, which leads to a 50% reduction in food waste per capita globally, by the year 2030".[4] In the European Union, under the auspices of the cohesion policy, food waste is addressed within the program called 'zero waste', launched in 2018, which supports active collaboration in order to monitor and reduce food waste throughout the supply chain (European Commission, 2019). In Romania, annual food waste amounts to 2.5 million tons, which means each citizen is wasting, on an average, 70 kilograms annually, a figure that places Romania in the middle of the European ranking of waste generators (Eurostat, 2022)[5].

The Ministry of Agriculture and Rural Development of Romania estimates that the food industry sector generates 37% of the waste; public food sector generates about 5% of the waste; and the agricultural sector generates 2% of the waste (IBA, 2021). Thus, food is thrown away even when there is a high number of over 4.6 million Romanians living in poverty (IBA, 2019) and an important percentage of the population is below the poverty line (21.2%) (low work intensity, in conditions of severe material deprivation) (Institute National of Statistics).[6, 7]

Considering the aforementioned points, this article seeks to assess food waste comprehensively and to scrutinize its implications for agro-tourism establishment in mountainous regions. Through these analyses, a set of measures and actions are delineated to bolster both public and private interventions in addressing food waste generation. The primary goal of this study is to assess the food waste in mountain area in Romania in order to develop policies providing better economic and social outcomes.

[1] The EPA are the primary data controllers under the European Union (Waste Directive) Regulations 2011-2021.
[2] https://www.usda.gov/media/blog/2022/01/24/food-waste-and-its-links-greenhouse-gases-and-climate-change
[3] https://posts.voronoiapp.com/climate/80-Million-Tons-of-Food-Waste-in-the-US--992
[4] Donald Tusk, President of the European Council, spoke at the 70th United Nations General Assembly (UNGA), https://www.consilium.europa.eu/en/meetings/international-summit/2015/09/26-30/
[5] https://t.ly/EU9xA
[6] https://www.statista.com/statistics/1191508/romania-poverty-rate/
[7] https://insse.ro/cms/

Firstly, it is defined what the food waste are with its negative effects on environment and society. Secondly, infrastructure of tourism capacities of mountain communities' areas were assessed. Thirdly, it estimated the total amount of food waste in the mountain area. Finally, it presents the many benefits that can be obtained from diminishing food waste.

Review of Literature

Literature reflects the need of recognizing the significance of reducing food waste. Literature emphasizes on examining the causes and sources of production (Schanes, Dobernig and Gözet, 2018), monitoring (Corrado and Sala, 2018), methods of control and mitigation (San Cristóbal, Fernández and Diaz, 2018; Belletti and Marescotti, 2020). The economic literature in this area primarily focuses on short-term (Campoy-Muñoz, Cardenet and Delgado, 2017), but also medium-term (Rutten, 2013) effects, demonstrating that the quantitative impact of reducing food waste is typically analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on different stages of the production and supply chain. The conclusions of the studies mentioned are frequently based on a phenomenon, which is ignored or reduced in terms of labelling, packaging and logistics within the food chain.

Nevertheless, it is still difficult to estimate the amounts and values of food waste (Bellemare, Dabney and Munos, 2017), primarily due to a lack of statistics and statistical information. The lack of an agreed-upon evaluation technique at the level of member states of EU, as well as the fact that multiple definitions of food waste exist, contribute to the problem's unpredictability (Scherhaufer *et al.*, 2018; Schanes, Dobernig and Gözet, 2018). The findings of a study conducted by Corrado and Sala (2018) need to be mentioned as evidence for the aforementioned. It demonstrates that the measurement of food waste flows on a European and even global scale can vary significantly depending on the choice of assessment methodologies, the inconsistent use of definitions, and the fact that food waste can be "avoidable or unavoidable" (Schneider, Martinez-Alier and Kallis, 2011). At the EU level, food waste per person ranged from 158 kg to 298 kg annually. Estimates of 76 kg per capita per year are based on 2006 data for the EU27 (Monier *at al.*, 2010) or 92 kg per capita per year (Stenmarck *et al.*, 2016), including edible and inedible scraps.

The evaluation of the advantages and disadvantages brought on by the decrease in food waste raises a concern (FAO, 2014; Schanes, Dobernig and Gözet, 2018). Microeconomic theory, it is argued, frequently falls short of capturing "real" consumption behaviour, which results from non-value (non-price) factors such as poor planning, aesthetic perceptions, and social factors like prestige, as well as the relationship between purchasing power and food options or those related to nutritional value. It can be challenging to evaluate cultural aspects as well as lifestyle factors (influenced by cuisine, nutritional knowledge, food management, storage, etc.), as well as ethical, ecological, and financial attitudes toward food waste in civilizations where food is plentiful and relatively inexpensive. A survey shows that in the US, over 37% of consumers always or usually throw away food that is near the date mentioned on the container under the name "best before" (Neff *et al*., 2019). Food labeling and packaging also fall under this category of criteria.

According to some experts (Williams, Wikström and Otterbring, 2012), 20–25% of food is lost during packaging, proving that bulk packaging and date marking are significant contributors to food waste. Therefore, it follows logically that improvements in food labeling and packaging (such as resalable, smaller, and divided packages, more detailed label instructions, time-temperature indications, and control) are essential for lowering household waste. There is even a perception that clearer indications on packaging can limit the additional cost for the retailer (Verghese *et al.*, 2015) or increase the benefits associated with incentive taxation (Schanes, Dobernig and Gözet, 2018).

The benefits of reducing food waste are not confined to a specific sector or area, but cover both upstream markets (e.g. feed, fertilizer use, land and labour) and food security benefits from reducing food imports (Hanson and Mitchell, 2018). Food waste assessment models are diverse. In an attempt to standardize them, a group of FAO experts (FAO, 2021; Ghamrawy, 2019) specialized in food security proposes a general equilibrium framework model that should be followed in case of food waste (Stenmarck *et al.*, 2016). They start from the theory of general equilibrium, in which market exchanges are based on the price system. The concept of "equilibrium" refers to the fact that such exchanges take place in such a way that all actors are satisfied and can produce new exchanges. The theory of general equilibrium is based on perfect competition (Arrow and Debreu, 1954) and certain working assumptions: there must be at least one price system, which equalizes the (global) offers and demands of economic agents (agents who behave as "participants at the price"). Other instances in the pertinent literature require the use of macroeconomic simulation models (such as the fixed-price social accounting matrix; Campoy-Muñoz, Cardenete and Delgado, 2017) or computable general equilibrium representations under flexible prices (Rutten, 2013; Rutten and Verma, 2014; Rutten *et al*., 2015; Rutten and Kavallari, 2016). Other methods by which food waste can be assessed are identified in the next table 1.

Table 1: General methods for evaluating food waste in each economic sector

Economic Sector	*Evaluation methods*					
Production	Direct Measurement	Waste composition analysis	Volume assessment	Quality assessment	Numbering, scanning	Food Journal
Commerce						
Food services						
Households						

Each EU member state has created unique tools targeted at managing, minimizing, and preventing food waste. Others take the form of various trash prevention techniques or programs, including national trash plans (Manfredi and Cristobal, 2016). In end, it is challenging to estimate how much food is wasted in each nation because it is frequently gathered alongside other wastes and cannot be tracked independently. The majority of home garbage falls into this category, but it also applies to other industries where food waste may be gathered and processed as bio-waste (Kader, 2005). Calculating the amount of avoidable food waste is much more challenging. The most common approaches call for separate sorting, which is frequently challenging to accomplish, to determine the generation of preventable and time-consuming food waste.

Considering the fact that there is no common methodology for evaluating food waste in the European Union, this article aims to evaluate the amount of this in the mountainous area of Romania. Based on quantities initially estimated by the Ministry of Agriculture, an attempt is made to show that, in the mountainous area, the amount of food waste is lower compared to other areas. In the mountainous areas, responsible tourism is practiced as a rule, when people take into account specifics of responsible tourism.

Methodology

Study Area

This study pertains to the mountain region in Romania, and tries to assess the total amount of food waste in touristic infrastructure (hotels, touristic pension, agro-touristic pensions, etc.). In Romania, mountain region occupies around 71,340 km^2, representing 29.93% of the total national surface and 20.14% of UAA (Utilised Agricultural Area). The mountain territory has about 3.2 million inhabitants (20% of the national population).

Mountain Area is overlapping almost 100% with the Carpathian Mountains. The average elevation value of the Carpathian Mountains is 1,136 m, and the highest altitude is over 2,500 m. Agricultural area existing in mountain region is around 2,802,000 ha. Out of this area, in 2007, only 1,290,000 ha (46%) was under cultivation, and in 2013 was about 2,520,000 ha (90%). Beyond this threshold, it is unlikely to be higher because of strict eligibility criteria referring to plots and farm sizes. Due to natural restrictive condition (slope and altitude), Carpathian Mountains encounter obstacles in farming, with a negative consequence (a shorter period of cropping period and supplementary costs).

The mountain region is characterized by a low productivity and depopulation. Mountain region in Romania differ from other regions due to natural disadvantages (i.e., elevation, climate, slope, low soil fertility, reduced access to the communication routes and markets), and structural disadvantages (i.e., ageing active population, migration trends, restricted jobs, distances from decisional centres, and insufficiently developed infrastructure).

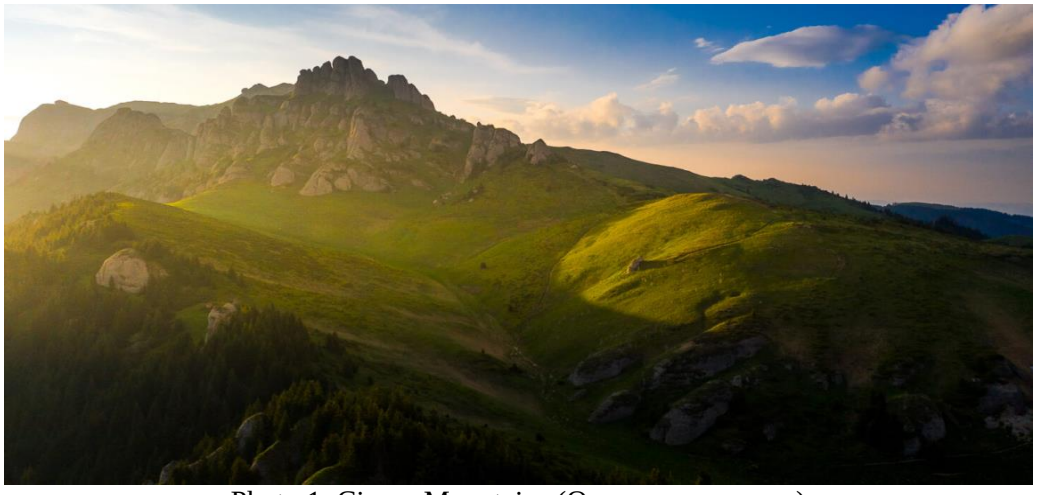

Photo 1: Ciucas Mountains (Open access source)

This article focuses on food waste from tourism infrastructure in mountain area of Romania. The information on the characteristics of food waste was collected from the website of National Institute of Statistics[8] in Romania, which provides independent information on the mountain tourism. The author conducted a thorough literature review focusing on keywords related to 'food waste'. This review involved identifying and analysing existing studies, reports, and articles that discussed food waste in various contexts. Based on the literature review, the author synthesized the information gathered and offered interpretations. This process involved analyzing the data to identify patterns, trends, and key insights regarding 'food waste'. Statistical analysis involved the data analysis using Microsoft Excel 2010.

Results and Discussion

Environmental Economics of Food Waste

Food waste starts right from production, continues throughout the supply chain till consumption. According to recent data published by the National Institute of Public Health[9] (2019) in Romania, food waste is estimated to be 6,000 tons per day, of which 50% is coming from households, 37% from the food industry, 7% from retail, 5% from public food and 2% from the agricultural sector. To combat this phenomenon, Romania's Food Waste Prevention Law, no. 217/2016[10] (corroborated with the provisions of Law no. 227/2015 on the Fiscal Code), covers the following measures:

1. responsibility for reducing food waste in the agri-food chain;
2. sale at a reduced price of products close to the expiry of the minimum durability date;
3. transfer of food by donation, for human consumption;
4. disposal and use of animal by-products and derived products;
5. directing agro-food products that have become unfit for human or animal consumption by turning them into compost;
6. directing agro-food products that have become unfit for human or animal consumption in order to capitalize on them by transforming them into biogas; and
7. directing to an authorized waste neutralization unit.

Food waste management is the process of recovering from the lost food, so less of it is produced in the first place. It's another issue that we often take for granted, but one that needs to be addressed in order to reduce the amount of food waste in our society. The loss of so much food means that, as a society, it is a waste of food every year. Reducing this waste has a number of benefits for the environment, as well as for our pocketbooks (European Commission, 2000).

At the national level, a strategic approach to the problem of food waste is necessary. This strategic approach is found in most EU-27 member states, and Romania still has problems in terms of food waste. The authorities and institutions responsible at the central level should sit down at the discussion table and propose a strategic national plan

[8] https://insse.ro/cms/en
[9] https://insp.gov.ro/en/the-national-risk-monitoring-center-from-community-environment-cnmrmc/reports/, RAPORTUL PENTRU SĂNĂTATE ȘI MEDIU 2022, the National Institute of Public Health, Romania.
[10] https://ec.europa.eu/food/safety/food_waste/eu-food-loss-waste-prevention-hub/eu-member-state-page/show/RO

to prevent food waste. The strategic approach considers the establishment of the following possible objectives:

- developing an annual plan to reduce food waste,
- carrying out internal communications with employees from different sectors on this topic,
- adapting production to certain existing market situations (demand-offer, ensuring traceability),
- waste reduction plan depending on the market and the place where it is produced,
- plan of education and information measures regarding the prevention of food waste,
- ways to quantify food waste,
- measures to redistribute/use benefits (where possible).

In Romania, per capita estimates of food waste are 70 kg/year[11], with urban areas producing more food waste. In rural areas, there is a tradition of consumption without much loss as a result of a high ethical sense, along with relatively low incomes and the use of traditional methods of valorizing household food scraps. The estimation of food waste took into account the interviews carried out in 2021 with the owners of agri-pensions in the mountain area of Romania. It was found that 15 kg of waste per tourist (about 21.4% of the national average of 70 kg per capita, annually) was generated. Given that this was a maximum value, and taking into account the trends identified at national level, food waste has decreased in 2020, compared to 2016, in all product categories with significant percentages in bakery products where decrease was 63.8% in 2020 compared to 2016. In case of the meals prepared at home, the decrease of food waste was 61.11% in 2020 compared to 2016.

The estimation of food waste in the tourist structures in the mountainous area of Romania was made based on the following working hypotheses, presented below:[12]

1. In restaurants, food waste is estimated at 15 kg per tourist per year;
2. In catering companies, 6 kg per tourist per year.
   a. The estimation of food losses in mountain tourist areas of Romania was based on the following work options, considering that not all mountain tourist structures have their own restaurants: 10 kg per tourist annually food waste produced in the average mountain areas;
   b. 15 kg per tourist per year, maximum option;
   c. 6 kg per capita annually minimum variant of waste produced in tourist accommodation structures.

Situation of Tourist Infrastructures in Mountain Area of Romania

The tourist capacity of the mountain areas in the year 2021 was 2,492 tourist accommodation structures, which represents 27.25%[13] of the total at the national level (National Institute of Statistics[14]). About 52.85% of the total accommodations are agro-

[11] https://romania.europalibera.org/a/romania-risipa-alimentara-proiect-lege/31873592.html
[12] National Research and Development Institute for Food Bioresources – IBA Bucharest, Annual Report 2022, https://iba-risipaalimentara.ro/studii/studiu-cercetare.pdf.
[13] http://statistici.insse.ro/tempoins/index.jsp?page=tempo3&lang=ro&ind=TUR103D
[14] Ibid

tourist guesthouses, followed by tourist guesthouses (17.47%), tourist villas (8.47%) and hotels (7.95%). Most are 3 stars and are agro-tourist guesthouses.

Table 2: Touristic structure by types of accommodation in mountain area of Romania, 2021 (%)

Accommodation type	*% of total*
Hotels	7.95
Hostels	2.09
Apartments	0.24
Motels	0.56
Touristic villas	8.47
Tourist cottages	5.82
Agri-tourism pensions	52.85
Camping	0.6
Tourist stops	0.6
Holiday villages	0.16
Bungalows	1.4
Pupil and preschool camps	0.64
Touristic houses	17.46
Total	100.00

Source: National Institute of Statistics of Romania [https://insse.ro/cms/en]

There are 66,374 accommodation places in the tourist accommodation structures in the mountain area (with an average of 27 places per tourist unit) (National Institute of Statistics [15]). About 32% of places are in agri-tourism guesthouses, followed by hotels (26.58%). In table 3, we can see the total arrivals (number of people) in the tourist reception units in the mountain area. It can be seen that there were 1,866,402 people in 2021, 44.6% more than in 2014 (National Institute of Statistics [16]).

Table 3: Arrivals of tourists in tourist reception structures in the mountain area of Romania, 2021[17]

Years	*Total arrivals of people (mill. Pers.)*
2014	1.291
2015	1.528
2016	1.748
2017	2.019
2018	2.217
2019	2.305
2020	1.295
2021	1.866

Source:[18]

[15] Ibid
[16] Ibid
[17] Ibid
[18] http://statistici.insse.ro/tempoins/index.jsp?page=tempo3&lang=ro&ind=TUR103F

The mountain tourist structures had an average degree of occupancy in 2021, that is 42.5% aggregate; the most occupied by hotels (52.8%), followed by tourist villas (36.5%). Mountain agro-tourist guesthouses had an occupancy rate of 23.1%, while tourist guesthouses were occupied at a rate of 26.2% (National Institute of Statistics[19]).

Table 4 presents the own estimates regarding the amounts of food waste within the tourist structures in the studied mountain areas of Romania. Thus, the most estimated waste is produced in hotels in the mountain area (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum). It is estimated in this study that the units in the HoReCa stores register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste). Compared to the total value estimated for the HoReCa stores, the food waste in the mountain area has a small size. It represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area).

Table 4: Estimates of total food waste quantities of tourist infrastructure in Mountain Area of Romania, taking into account different scenarios (6, 10 and 15 kg/bed/annum)[20]

Accommodation type	*Occupied beds annual*	*6 kg food wasted*	*10 kg food wasted*	*15 kg food wasted*
Hotels	9,588	57,527.7	95,879.52	143,82
Hostels	468	2,809.0	4,681.6	7,022.4
Motels	250	1,497.3	2,495.5	3,743.25
Touristic villas	1,584	9,506.8	15,844.65	23,766.98
Tourist cottages	929	5,571.1	9,285.1	13,927.65
Tourist guesthouses	2,132	12,791.4	21,318.94	31,978.41
Agri-tourism pensions	3,592	21,550.9	35,918.19	53,877.29
Camping	220	1,320.2	2,200.32	3,300.48
Tourist stops	139	833.7	1,389.53	2,084.295
Holiday villages	40	239.9	399.9	599.85
Bungalows	83	498.2	830.25	1,245.375
Pupil and preschool camps	470	2.820	4,701.13	7,051.695
Touristic houses	115	690.5	1,150.8	1,726.2
Total	16,614	99,684.6	166,141	249,211.5

Moving forward with the analysis, it is found that not all infrastructures in the mountain area are equipped with restaurants or shops, the most important are hotels (34%), agro-tourist guesthouses (22%) and tourist guesthouses (20.13%)[21]. This aspect complements the previous conclusion, in the sense that food waste is produced, in particular, in tourist infrastructures that also have restaurants or shops.

[19] http://statistici.insse.ro/tempoins/index.jsp?page=tempo3&lang=ro&ind=TUR103F
[20] The estimate of food waste was calculated per total category of infrastructure, annually, taking into account three variants of waste generation categories (maximum, average and minimum).
[21] https://insse.ro/cms/en

A Scenario with High Potential Impact on Reducing Food Waste

The packaging process is vital in maintaining the quality and safety of food. It extends increased shelf life to the stored product, thus reducing food waste. However, packaging is used, in turn, for a product with a short life cycle. Therefore, its incorrect management can lead to negative effects on the economy and the environment. Packaging has a direct link to the circular economy, which promotes closing the loops in industrial systems, minimizing waste and reducing the input of raw materials and energy. From the perspective of the circular economy, the food chain includes three important stages: food production, consumption and food waste generation, including food surplus management (De Laurentiis, Caldeira and Sala, 2020).

Currently, the food journey "from farm to consumer" shows the need for packaging systems that facilitate the protection, transport and storage of food products. In this context, packaging could significantly contribute to reducing food waste. Therefore, it is recommended to continue the development of new forms of distribution of packaging for food products, which minimize handling along the supply chain. Reusable boxes and pallets are two examples of packaging that reduces the amount of product handling. Food and packaging have a special connection (Duizer, Robertson and Han, 2009). Correct food packaging utilization can reduce family food waste and the negative environmental implications of overproduction. That is why it is important to recognize the potential trade-off between packaging consumption and food waste. In this sense, it is well known that packaging contributes to sustainable development by maintaining the quality of products in the supply chain. There are studies showing that packaging can be an interesting and attractive topic because people have become more aware of packaging waste than food waste (they usually underestimate the amount of food waste) (Duizer, Robertson and Han, 2009).

Packaging is one of the most studied methods of reducing food waste. It has an important concern because of the impact on the environment versus the generation of waste. For instance, although the likelihood of food waste generation is low, the switch to single-serving sizes in some food categories may result in a high amount of packing per unit mass of food. To achieve the optimum environmental result, it becomes crucial to understand and research the trade-off between packaging usage and food waste. Packaging can be classified as follows:

- Primary packaging for retail (plastic, glass, metal, etc.);
- Secondary/tertiary packaging: additional layers that contain and protect the primary packaging during distribution (examples: corrugated cardboard boxes, plastic or wooden pallets, plastic crates for processed foods or stretch films).

The most used materials are polymeric (37% - in the flexible version 10% and rigid 27%) due to the properties that can ensure the quality of the packaged products throughout their lifetime until consumption.[22] The types of polymer packaging are: trays, boxes, casseroles, bags, films, sealable foil, cups, vacuum bags, etc. These types of packaging must comply with certain specific quality conditions for the entire duration of both transport and the life of the food products. The phases of the packaged food supply chain

[22] https://europlas.com.vn/en-US/blog-1/what-is-flexible-plastic

must be identified in order to calculate food loss due to packaging. There are various phases and causes of food waste along the supply chain: A product may lose some of its contents after being packaged for sale or transportation. The packaging must present a series of characteristics, for example they must be easy to open and empty. If these characteristics are not met, food waste occurs quickly (by spillage). An estimate based on studies showed that food loss and food waste caused by packaging contributes with 20-25% of the total amount of household food waste (Table 5) (Wohner *et al.*, 2019).

Table 5: Types of food waste caused by packaging damage

Phase	*Types of food waste caused by packaging damage*	
On the supply chain	Post-harvest handling and storage	Damage caused by various contaminants, sharp edges, chips from storage containers.
	Processing and packaging	Problems in the filling process; Packaging failures during sealing; Changes to packaging for marketing reasons.
	Distribution	Inadequate packaging material, poor stability; damage to barcodes.
In households		Packaging difficult to open or empty; Incorrect size.

Source:[23]

According to European Regulation 450/2009[24], the main design criteria that an ideal package must fulfil are: zero toxicity, easy handling, adequate mechanical strength, firm closing characteristics (such as resealing), and moisture control, appropriate labelling. The main benefits of reducing food waste by using innovative packaging are:

- Save money by reducing overbuying and disposal costs;
- Reduces the impact on the environment;
- Supporting efforts to eliminate hunger;
- Reduction of health-related problems; elimination of odours;
- Supporting community efforts to reduce waste;
- Increasing fiscal benefits through food donation;
- Energy conservation and reduction of greenhouse gases.

Food safety is also taken into account. So, the primary cause of food-borne illnesses is still microbial contamination of food products. Market globalization, which calls for items with longer shelf lives, and the rise in popularity of minimally processed foods present further difficulties. As a result, new food packaging materials that ensure safety and retain quality over extended periods of time are required. Food packaging technology is continually changing to meet these difficulties.[25] Table 6 lists several potential technological advancements for packaging-related food waste reduction.

In order to extend shelf life by interacting with the product (e.g., by releasing antioxidants, antimicrobials, or oxygen scavengers), food packaging must transition

[23] https://foodprint.org/issues/the-environmental-impact-of-food-packaging/
[24] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:135:0003:0011:EN:PDF
[25] https://www.who.int/news-room/fact-sheets/detail/food-safety

from a passive one (a simple container that protects its contents from moisture, air, microbes, and mechanical damage such as vibrations and shocks) to an active one. "Smart" or "interactive" packaging solutions[26] can help with corroboration and data sharing in the supply chain. For better demand feedback for different supply chain actors, smart food packaging can offer real-time expiration data, product tracking, and temperature indicators that are either time-based or triggered by specific chemicals, determined by radio frequency identification (RFID)[27] data, or have thermal sensors. By relaying information to suppliers about quality, safety, shelf life, and logistical effectiveness, these smart packaging solutions have the potential to decrease food waste in the supply chain.

Table 6: Innovative food packaging technologies to reduce food waste

- Improved mechanical, thermal, and barrier qualities of packaging
- Increased biodegradation due to biodegradability
- Shelf life extension, oxygen scavenger, and antimicrobial active packaging
- Environmental interaction, self-cleaning, self-healing, and damage signalling are all features of smart packaging
- Controlled distribution and release: bioactive substances (like essential oils) and nutraceuticals
- Monitoring of the state of the product: gas detector, freshness indicator, leak indicator, and temperature time indicator (TTI)
- Nanosensors: monitoring microbial growth and food quality
- Nanocoatings
- Nano-barcode and product authentication information.

Source:[28]

By minimizing the amount of time products spend in the supply chain, you may increase shelf life and lessen the chance that they will spoil while being transported or stored. Under these circumstances, nanotechnology is being investigated more and more as a tool for the creation of active food packaging. The result is that NanoPack[29] is an active packaging film with antimicrobial properties that gradually releases tiny amounts of antimicrobial essential oils in the form of vapours into the so-called "headspace" of the package, sanitizing both the food product and the headspace and extending the shelf life of the product. By adding three weeks to the shelf life of bread without additions, NanoPack films show the potential of active packaging technologies to cut down on food waste.

Plastics and metallized films that provide a high mechanical barrier and are impervious to water, oxygen, and microorganisms are in high demand because they can extend shelf life while using fewer preservatives. Some materials are not biodegradable and are frequently made from non-renewable fossil fuel sources (Wikström, Williams, Verghese and Clune, 2014).

[26] https://www.packaging-gateway.com/features/exploring-smart-interactive-flexible-packaging/
[27] https://www.techtarget.com/iotagenda/definition/RFID-radio-frequency-identification
[28] https://www.packworld.com/sustainable-packaging/article/22552118/active-packaging-innovations-help-minimize-food-waste
[29] https://www.bbeu.org/projects/nanopack/

Materials with numerous functional layers frequently have limited options for recycling or disposal. Additionally, there is widespread worry across the globe regarding the environmental effects of packaging trash made of persistent plastic in particular. As a result, there is a growing trend towards environmentally friendly choices that are more sustainable.

Because they are more readily biodegradable or compostable than typical plastic packaging, bio-based materials are being investigated as environmentally friendly alternatives. However, due to their characteristics (such as greater permeability to air or water), their industrial use and application are still restricted. If conventional plastic is to be replaced and the waste issue is to be solved, these qualities must be considerably enhanced (Vera, Bowman and Mechielsen, 2022).

An example of good practice is the RefuCoat project[30], financed by EU funds[31], which proposes the development of two new types of bio-food packaging. The first is an active packaging alternative that is totally recyclable to the metallized foils typically used to package cereal, crisps, and salty snacks. A completely biodegradable container for chicken products is the second option. Active packaging technologies extend the time that food may be carried, reducing the loss and waste caused by food spoilage, while other cutting-edge concepts enable waste to be eliminated or turned into useful resources. These technical advancements may prove to be a vital weapon in the worldwide struggle against food waste.

Making food packaging a by-product of the food business is another ground-breaking suggestion for enhancing the sustainability of food packaging. By employing by-products that would typically be lost, such as unpurified cheese whey and almond shells, the community initiative YPACK[32] (2017) is creating a 100% recyclable packaging film and a fully biodegradable packing tray. The tray includes active antibacterial qualities that can increase the shelf life of food goods, while the related flow pack material serves as a passive barrier.

Taking into account the fact that plastic packaging is found everywhere in nature around the world (in ocean waters, rivers, mountains, forests, cities, etc.) and the fact that much waste can no longer be sorted or recycled, we believe that the impact of a smart packaging would be great (Quested, 2019). To stop this waste from expanding on a large scale, it is important that certain laws are passed to protect the sale of bags and other packaging made of plastic or non-renewable materials.
In Romania, Law no. 87/2018[33] promulgated on January 1, 2019 regarding the management of packaging and packaging waste prohibits the sale of plastic bags (thin plastic bags with handles, 50 microns thick). In order to reduce the presence of these bags and to interfere with the illegal system of buying surplus bags in other countries, it

[30] RefuCoat seeks to develop hybrid bio-based high oxygen/water barrier and active coatings to be used in monolayer bio-based packaging (films and trays) as alternative to current metallized and modified atmosphere (MAP) packages.
[31] https://www.cbe.europa.eu/projects/refucoat
[32] YPACK brings together the necessary competence and resources to ensure the achievement of the project goals and ensure an impact of these results at both European and international level. YPACK consortium consists of a multidisciplinary team of 21 partners from 10 European Union member countries or associated. These partners are key actors and stakeholders in the field of food novel packaging, including raw material researchers and developers, packaging manufacturers, food retailers and producers, and consumers research.
[33] https://nicholasinstitute.duke.edu/sites/default/files/plastics-policies/2467_N_2018_Law_no_87_Amending.pdf

is important to change the green tax. As a result, plastic bags have been partially removed from the commercial system and replaced with biodegradable and compostable bags, which are more environmentally friendly. The costs vary starting from 0.10 lei/bag and reaching 0.15 lei/bag. The problem is the incorporation of natural safeguards, which are intended to include thin plastic bags without handles. The SR EN 13432: 2002 standard[34] applies to products that meet certain standards in the field of biodegradable and compostable objects. Therefore, to be approved, the packaging must meet certain criteria: *a have a shelf life of 12 weeks until the product degrades almost completely*. Except for carbon dioxide, a biodegradable bag emits no harmful substances into the atmosphere. There is a difference between biodegradable products and compostable products: biodegradable items are not entirely beneficial to the environment. They also have plastic components and microorganisms that help break it down. Compostable items are made from organic materials such as corn-starch. Therefore, if such objects or packages, including bags, are used more and more, nature has many benefits.

Conclusions

In conclusion, the specialized literature in the field emphasizes the short-term (Campoy-Muñoz, Cardenete and Delgado, 2017) as well as the medium-term (Rutten *et al*., 2013) effects, demonstrating that the quantitative impact of reducing food waste is typically analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on various stages of the production and supply chain. The conclusions of the studies mentioned are frequently based on estimates of the occurrence due to the absence of statistical data. Thus, most of the time, the supply perspective of the phenomenon is ignored or reduced in terms of labelling, packaging and logistics within the food chain.

Each EU member state has created unique tools targeted at managing, minimizing, and preventing food waste. Others take the form of various trash prevention techniques or programs, including National Trash Plans. Additionally, it is challenging to estimate the amount of food waste generated by each nation because it is frequently collected alongside other debris and cannot be tracked independently. The majority of home garbage falls into this category, but it also applies to other industries where food waste may be gathered and processed as bio-waste. Calculating the amount of avoidable food waste is much more challenging. The most common approaches call for separate sorting, which is frequently challenging to accomplish, to determine the generation of preventable and time-consuming food waste.

Taking into account the presented elements, the most estimated food waste is produced in hotels in the mountain area in Romania (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum. According to estimates, the units in the HoReCa sector register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste). Compared to the total value estimated for the HoReCa sector, the food waste in the mountain area in Romania has a small size, it represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area). Starting from these

[34] https://magazin.asro.ro/ro/standard/29283

global estimates, we believe that a more accurate assessment of the quantities of food waste is necessary, which takes into account each activity sector separately. Moreover, it is necessary to standardize the amount of waste for each sector, so that the estimate is as close as possible to the real situation.

The present article tried to give a brief picture of what the phenomenon of food waste means and the importance of actions that address, directly or indirectly, its reduction. Thus, academic research as well as certain practical techniques indicate the acknowledgement of the significance of decreasing food waste, with the pertinent objectives being the analysis of the primary causes and sources, ongoing monitoring, and promotion of control and reduction strategies. By reducing food waste, many benefits can be obtained: for health (reduction of diseases, avoidance of premature mortality etc.), resource savings (resource savings from forestry, agriculture and fishing), ecosystem benefits, social benefits (food bank, donations) etc. It has also been found that the use of certain packaging that uses different innovative materials can lead to a number of benefits, such as: saving money by reducing over buying and disposal costs; reducing environmental impact; supporting efforts to eliminate hunger; reducing health-related problems; eliminating odours; supporting community efforts to reduce waste; increasing tax benefits through food donation; conserving energy and reducing greenhouse gases.

In conclusion, regardless of the means or tools to reduce food risk, it is necessary, first of all, to be aware of the size and intensity of the phenomenon and must be acted upon as such. Decision-makers, together with individual consumers, production or marketing units, must work together to identify the best solutions and measures, which ensure the achievement of the goal of reducing food waste per capita by 50% globally, at the level of the year 2030.[35]

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[35] https://www.consilium.europa.eu/en/meetings/international-summit/2015/09/26-30/

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Author's Declarations and Essential Ethical Compliances

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

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The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

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